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PCT

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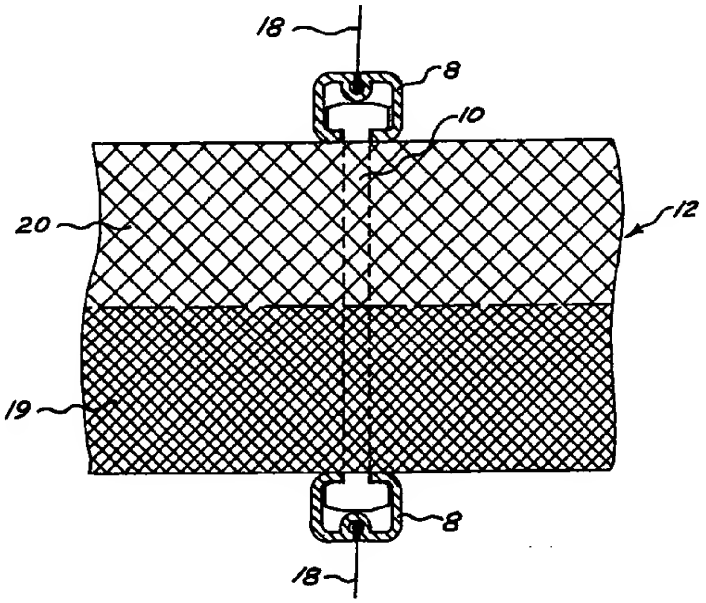

(57) Abstract

A rotary, parallel plate, regenerative dehumidifier comprises a rotor, itself comprising a multi-spoked frame supporting a spirally wound, plastics film ribbon (12) coated on both surfaces with a desiccant. Gas may flow axially through the rotor between the turns of ribbon so as to contact the desiccant thereon. The rotor is encircled by a casing and circumferential and diametral seals define two gas flow passages extending in the axial direction through the rotor. In use, gas to be dried flows through one said passage and a desiccant regenerating gas flows in the opposite direction through the other. The desiccant on the ribbon comprises silica gel covering that half (20) of the ribbon first met by the gas to be dried and sodium type X zeolite covering the other half (19) of the ribbon. The dehumidifier functions more efficiently than a like dehumidifier in which the ribbon is wholly coated with either desiccant alone.

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DEHUMIDIFIER

TECHNICAL FIELD

This invention relates to dehumidifiers for drying gases of the kind which operate by passing a stream of the gas to be dried over or about a desiccant. In those instances in which the dehumidifier is intended for more or less continuous or long term operation it is usual for it to include regenerating means whereby spent or used desiccant is regenerated for further use. Frequently those regenerating means direct a stream of warm, dry, regenerating gas over or about the desiccant, which is exposed alternately to the gas to be dried and to the regenerating gas in a continuous cycle.

Typically such dehumidifiers are used in air conditioning systems wherein the gas to be dried is outside air entering the system and the regenerating gas is heated exhaust air from the conditioned space.

BACKGROUND ART

The invention was developed utilising a so-called parallel plate dehumidifier, wherein the desiccant is a surface coating on a matrix of closely spaced substrate layers with their width dimensions parallel to the direction of flow of the gas. Thus it is described hereinafter primarily with reference to that type of dehumidifier, but it will be appreciated that it is applicable quite generally to other types of regenerative dehumidifiers.

The terms "upstream" and "downstream" are used herein with reference to the direction of flow of the outside air or other gas to be dried.

For descriptive convenience, the terms "sector", "circumferential", "diametral" and others related to a circle, are used herein, where necessary, to embrace analogous concepts related to approximate circles which are in fact polygons. Likewise, the terms "spiral" and "spirally", which usually refer to a smooth curve, are used herein to refer also to near spirals comprising a series of angularly related straight lines. Indeed, all those terms are intended to be construed as relating not only to true circles and spirals but also, at the limit, to substantially triangular arrangements.

Parallel plate, regenerative dehumidifiers are known wherein a stream of gas to be dried flows through one sector of a disk shaped matrix and a stream of regenerating gas flows through another sector of the same matrix, and wherein the matrix revolves about its own axis so that each part of it is periodically exposed to each gas stream in turn. In such dehumidifiers, usually referred to as rotary dehumidifiers, sliding seals are provided between the rotating matrix and its surrounding stationary structure to define and separate the two gas streams. Those seals comprise a circumferential seal and two radial seals. Usually the radial seals are aligned so as to form a single diametral seal, so that each said sector is substantially a semi-circle.

It is also known, in other contexts, to dehumidify a quantity of material by exposing it to a first desiccant, perhaps a cheap desiccant provided in large amount, to extract the bulk of the moisture, and then to a more aggressive desiccant to remove the final vestiges of

moisture; but hitherto that technique has been restricted to manual laboratory operations and the like.

DISCLOSURE OF THE INVENTION

An object of the present invention is to provide a regenerative dehumidifier which is more operationally effective than prior known dehumidifiers.

The invention achieves that object primarily by providing a dehumidifier of the kind comprising means to direct a stream of moist gas to be dried into contact with a desiccant, characterised in that the desiccant comprises at least two components which are segregated in the direction of gas flow so as to be exposed to the moist gas stream sequentially.

In preferred embodiments there are means to regenerate the desiccant by directing a stream of dry regenerating gas into contact with the desiccant. In those instances the positions of the desiccant components are preferably chosen for optimum response to the operating conditions in both of the gas streams at their respective positions of exposure. This requires the regenerating gas stream to contact the segregated desiccant components in the reverse order to that of the moist gas stream. This is achievable either by changing the positions of the desiccant components or arranging for the moist gas and the regenerating gas to flow in opposite directions relative to the desiccant. The latter is preferred.

BRIEF DESCRIPTION OF THE DRAWINGS

By way of example, an embodiment of the above described invention is described in more detail hereinafter with reference to the accompanying drawings.

Figure 1 is a diagrammatic perspective view of a rotary type parallel plate dehumidifier.

Figure 2 is a plan view of a short length of the peripheral surface of the rotor of the dehumidifier of figure 1 as it would be seen if viewed in the direction of the arrow 2 of that figure, showing the desiccant arranged as segregated components in accordance with the invention.

Figure 3 is portion of a vertical diametral section of the dehumidifier of figure 1 taken on line 3–3 of that figure.

Figure 4 is a graphical representation of the results of comparative tests on dehumidifiers according to the invention and dehumidifiers according to the prior art.

BEST MODE OF CARRYING OUT THE INVENTION

The illustrated dehumidifier is conventional in all respects except for the division of its desiccant into two segregated components of differing characteristics.

Briefly stated its conventional mechanical structure comprises a rotor 4, itself comprising a frame and a flow–through matrix 5,

comprising a plurality of spaced apart, axially extensive, substrate layers (the "plates" of this parallel plate humidifier), supported by said frame, drive means 6 to rotate the rotor about its axis, a casing 7 encircling the rotor 4, circumferential and radial sealing means to define two, stationary, gas flow paths extending respectively through upper and lower, substantially semi-circular sectors of the matrix 5 and a surface coating of desiccant adhered to and substantially covering said substrate layers.

In this instance the rotor frame comprises two axially spaced apart spiders, each comprising a plurality of spokes 8 extending from a central hub 9, a plurality of spacers 10 extending from respective positions on the spokes 8 of one spider to corresponding positions on the spokes 8 of the other and an outer cover sheet 11.

The matrix 5 comprises a tensioned, thin plastics ribbon 12, for example, of Mylar film, wound spirally upon the spacers 10. Each flight of that ribbon 12 extending from spacer to spacer constitutes a substrate "plate" of the parallel plate dehumidifier.

The casing 7 comprises an outer drum 13 and cross-beams 14 furnished with bearings supporting the hub 9.

The drive means 6 comprise a motor and worm gear unit 15 mounted on the drum 13 and driving a friction drive roller 16 making contact with the cover sheet 11.

The circumferential sealing means of the illustrated dehumidifier comprise a resilient plastics or like band 17 underlying the cover sheet and projecting axially beyond it into sliding contact with circumferential

edge flanges on the drum 13. The diametral sealing means comprise resilient plastics or like fins 18 extending along each of the spokes 8 adapted to make sealing contact with the inner faces of the cross-beams 14. The arrangement is such that the fins 18 of one pair of radially aligned spokes come into contact with a cross-beam 14 just prior to the fins of the pair ahead breaking contact therewith, to maintain a substantially continuous seal. In other embodiments there may be some intended leakage at the diametral seal but this is conventional and not germane to the present invention.

Thus it will be apparent that the sealing means define two flow paths extending axially through the matrix 4, each of substantially semi-circular cross-section and disposed one above and one below the cross-beams 14 as drawn in figure 1. It will also be apparent that as the rotor turns each part of the matrix is alternately exposed to the gases flowing in the respective paths, namely the gas to be dried and the regenerating gas. In use in an air conditioning system, the dehumidifier would be mounted within a divided circular duct whereby incoming fresh air and exhaust air from the conditioned space, being the gas to be dried and the regenerating gas respectively, are passed through the dehumidifier in opposite directions and are kept separate from each other.

As indicated in figure 2 the desiccant coating both sides of the ribbon 12 is segregated into two components applied respectively to an upstream zone 19 and a downstream zone 20 of each side of the ribbon. The characteristics of the two desiccant components differ from each other. In the present instance the desiccant component covering the upstream zone 19 of each side of the ribbon is silica gel

and that covering the downstream zone is sodium type X zeolite (NaX), an alumino-silicate with molecular porosity.

A significant parameter of a desiccant medium is its reduced isotherm slope, which is defined as the rate of increase in the moisture content of the medium with relative humidity of the ambient gas divided by the specific heat of the dry medium. In this definition, in the present context, the medium is the desiccant proper and its supporting substrate film. The reduced isotherm slope varies from one desiccant to another and for the one desiccant differs at different relative humidities. An effective desiccant for a given situation is one with a high reduced isotherm slope for the operating states at the situation concerned. The invention recognises this in that in dehumidifiers according to the invention each component of the desiccant is positioned where its reduced isotherm slope is the higher or highest for the local mean operating state.

For typical air conditioning applications two desiccant zones suffice and the zones may be of approximately equal width. However, in other more sophisticated embodiments of the invention, three or more different desiccant components may be used segregated into a corresponding number of zones. In either instance the zones may be of different widths.

In the illustrated preferred embodiment the spirally wound ribbon matrix is formed from a single ribbon, with all desiccant components, usually only two, adhered to discrete zones of it. Thus, if the ribbon is say 100 mm. wide, each zone may be a stripe of the ribbon's surface substantially 50 mm. wide extending for the length of the ribbon.

One ribbon is preferred because it is easier to wind on ribbon than it is to wind two or more parallel ribbons, bearing in mind that the spacers 10 have to be individually attached to the spider spokes 8 as winding proceeds. Nevertheless in other embodiments each layer of the matrix may comprise two or more parallel ribbons disposed side by side. Those ribbons would be wound on simultaneously, and each would preferably be fully coated with a respective one of the desiccant components.

This invention reduces the mass and cost of the materials to produce a dehumidifier and improves its performance by allowing it to dry air to a lower humidity with less regeneration heat.

In this regard attention is directed to figure 4 of the drawings which shows two sets of graphs illustrating the performance of the above described dehumidifier of the invention utilising segregated silica gel and NaX, compared with the performances of identical dehumidifiers, except that in one instance only silica gel was used and in the other instance only NaX was used. For all the graphs the relevant characteristics were reduced to dimensionless parameters before plotting.

The top set of graphs are plots of the "Coefficient of Performance" against a dimensionless length. That coefficient is a measure of the thermal efficiency of the dehumidifier taking into account the heat needed for regeneration of the desiccant.

The bottom set of graphs are plots of the "Cooling Effect" of the dehumidifier as a component in a building air conditioning installation, that is to say the specific latent heat difference, between the

regenerating air entering the humidifier and the dehumidified air leaving the dehumidifier, brought about by the dehumidifier, .

It will be seen that in both instances the NaX only units performed better than the silica gel only units, but that the dehumidifier according to the invention performed better than either.

CLAIMS

1. A dehumidifier of the kind comprising means to direct a stream of moist gas to be dried into contact with a desiccant, characterised in that the desiccant comprises at least two components which are segregated in the direction of gas flow so as to be exposed to the moist gas stream sequentially.

2. A dehumidifier according to claim 1 further characterised in that an upstream one of said desiccant components is silica gel and a downstream one of said components is sodium type X zeolite.

3. A dehumidifier according to either claim 1 or claim 2 further comprising means to regenerate said desiccant.

4. A dehumidifier according to claim 3 wherein said means to regenerate the desiccant comprise means to direct a stream of regenerating gas through the dehumidifier in a direction opposite to the flow direction of the moist gas.

5. A rotary regenerative dehumidifier of the kind comprising a rotor, itself comprising a frame and a flow-through matrix comprising a plurality of spaced apart, axially extensive, substrate layers, supported by said frame, drive means to rotate the rotor about its axis, a casing encircling said rotor with circumferential and radial sealing means to define two, stationary, gas flow paths extending through respective sectors of the matrix and a surface coating of desiccant adhered to and substantially covering said substrate layers, characterised in that each side of each said layer has at least two axially discret surface zones and in that the desiccant component on

each zone of each side has different properties from that on the other, or each other, zone on that side.

AMENDED CLAIMS
[received by the International Bureau on 3 September 1991 (03.09.91); original claims 1-5 replaced by amended claims 1-9 (2 pages)]

1. A rotary regenerative dehumidifier of the kind comprising a rotor (4), itself comprising a frame and a flow-through matrix (5) comprising a plurality of spaced apart, axially extensive, substrate layers supported by said frame, drive means (6) to rotate the rotor about its axis, a casing (7) encircling said rotor with circumferential and radial sealing means (17 and 18) to define two, stationary, gas flow paths extending through respective sectors of the matrix and a surface coating of desiccant adhered to and substantially covering said substrate layers, characterised in that each side of each said layer has at least two axially discrete surface zones (19 and 20) and in that the desiccant component on an upstream zone (19) of each side has different properties from that on a downstream zone (20) on that side, such that each component is positioned where its reduced isotherm slope is the higher or highest for the local mean operating state.

2. A dehumidifier according to claim 1 wherein the rotor frame comprises two axially spaced apart spiders, each comprising a plurality of spokes (8) extending from a central hub (9), a plurality of spacers (10) extending from respective positions on the spokes (8) of one spider to corresponding positions on the spokes (8) of the other and wherein said matrix (5) comprises a tensioned, thin plastics ribbon (12), wound spirally upon the spacers (10); each flight of that ribbon (12) extending from spacer to spacer constituting a said substrate layer.

3. A dehumidifier according to claim 2 wherein the upstream and downstream zones of said ribbon are coated with their respective desiccants before the ribbon is wound upon said spacers.

4. A dehumidifier according to claim 1 wh rein the rotor frame comprises two axially spaced apart spiders, each comprising a plurality of spokes (8) extending from a central hub (9), a plurality of spacers (10) extending from respective positions on the spokes (8) of one spider to corresponding positions on the spokes (8) of the other and wherein said matrix (5) comprises at least two tensioned, thin plastics ribbons, wound spirally side by side upon the spacers (10); each flight of each ribbon extending from spacer to spacer constituting a said zone of a said substrate layer.

5. A dehumidifier according to claim 4 wherein said ribbons are coated with their respective desiccants before being wound upon said spacers (10).

6. A dehumidifier according to any one of the preceding claims wherein the upstream zone (19) is coated with silica gel particles.

7. A dehumidifier according to any one of claims 1 to 5 wherein the downstream zone (20) is coated with sodium type X zeolite crystals.

8. A dehumidifier according to any one of claims 1 to 5 wherein the upstream zone (19) is coated with silica gel particles and the downstream zone (20) is coated with sodium type X zeolite crystals.

9. A dehumidifier according to claim 8 wherein said upstream and downstream zones (19 and 20) are substantially equal in width.

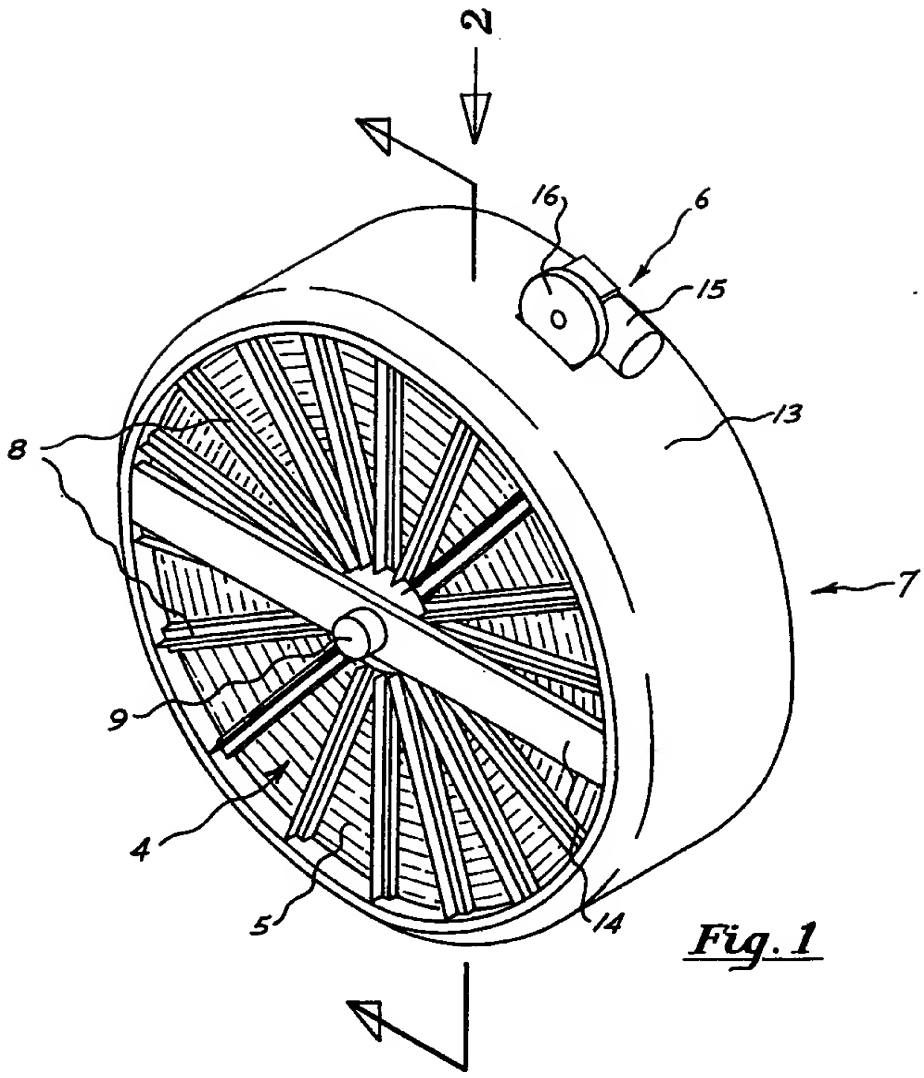

Fig. 1

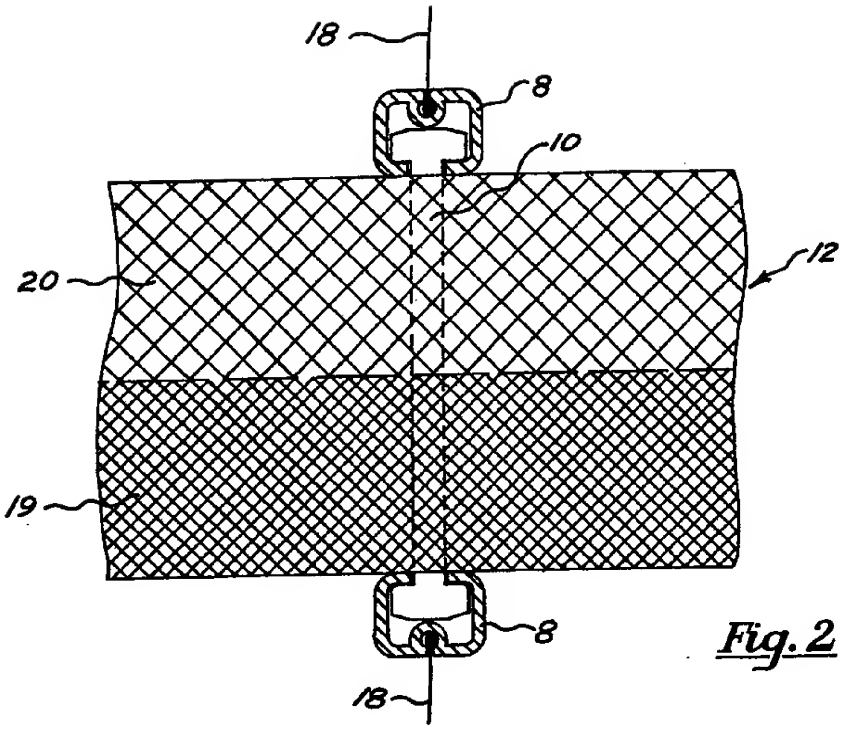

Fig. 2

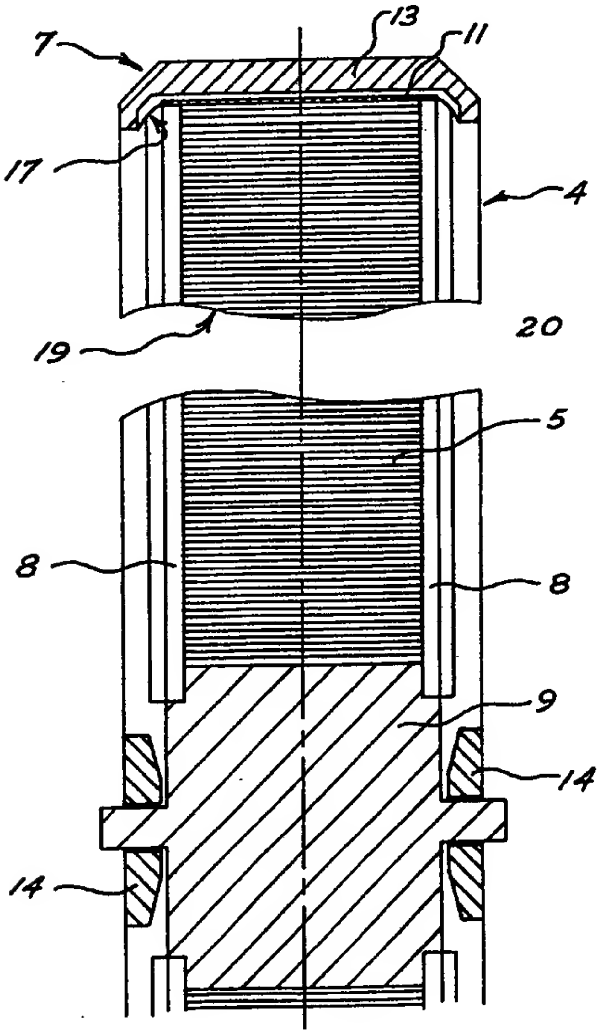

Fig. 3

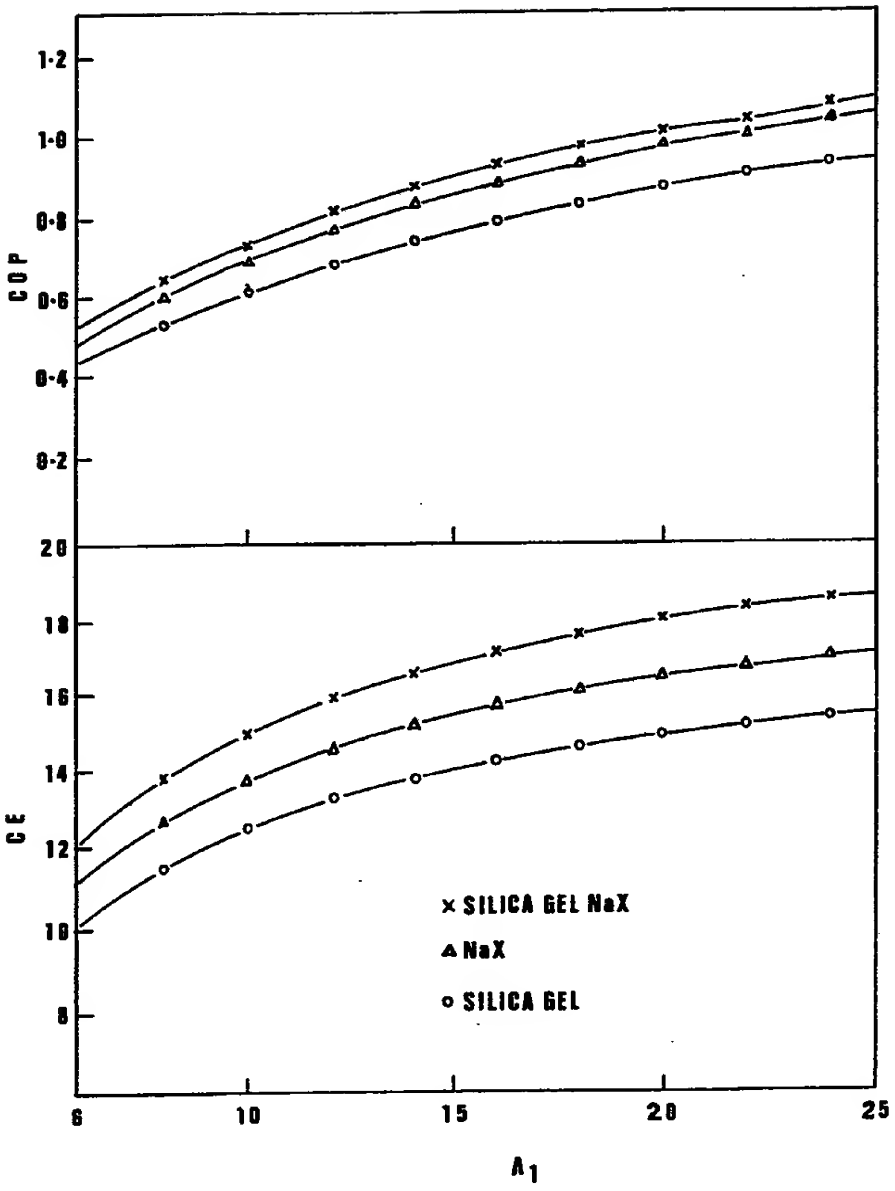
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Fig. 4

INTERNATIONAL SEARCH REPORT

International Application No. PCT/AU 91/00191

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 6

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.[5] B01D 53/28, B01J 20/18

II. FIELDS SEARCHED

Minimum Documentation Searched 7

Classification System	Classification Symbols
IPC	B01D 53/28, B01J 20/18

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 8

III. DOCUMENTS CONSIDERED TO BE RELEVANT 9

Category*	Citation of Document, [11] with indication, where appropriate, of the relevant passages 12	Relevant to Claim No 13
X	US,A, 4636225 (KLEIN) 13 January 1987 (13.01.87)	(1-4)
X	US,A, 3807149 (NORBACK) 30 April 1974 (30.04.74)	(1-4)
X	AU,B, 259519 (8905/61) (SOCONY MOBIL OIL COMPANY) 2 May 1963 (02.05.63)	(1-4)

* Special categories of cited documents: 10

"A" document defining the general state of the art which is not considered to be of particular relevance

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
3 July 1991 (03.07.91)	8 July 1991
International Searching Authority	Signature of Authorized Officer
Australian Patent Office	G. CARTER

Form PCT/ISA/210 (second sheet) (January 1985)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

V. [ ] OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE 1

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.[ ] Claim numbers ..., because they relate to subject matter not required to be searched by this Authority, namely:

2.[ ] Claim numbers , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3.[ ] Claim numbers ..., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4 (a):

VI. [ ] OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING 2

This International Searching Authority found multiple inventions in this international application as follows:

1.[ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2.[ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3.[ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. [ ] As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

[ ] The additional search fees were accompanied by applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON
INTERNATIONAL APPLICATION NO. PCT/AU 91/00191

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Members			
US 3807149	DE 2127138	FR 2096024	GB 1351527	
US 4636225	DE 3410815 ZA 8502155	EP 160180	IN 164791	

END OF ANNEX